Autogenous versus prosthetic vascular access for hemodialysis: A systematic review and meta-analysis

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Objectives: **The autogenous arteriovenous access for chronic hemodialysis is recommended over the prosthetic access because of its longer lifespan. However, more than half of the United States dialysis patients receive a prosthetic access. We conducted a systematic review to summarize the best available evidence comparing the two accesses types in terms of patient-important outcomes.**

Methods: **We searched electronic databases (MEDLINE, EMBASE, Cochrane CENTRAL, Web of Science and SCOPUS) and included randomized controlled trials and controlled cohort studies. We pooled data for each outcome using a random effects model to estimate the relative risk (RR) and its associated 95% confidence interval (CI). We estimated inconsistency caused by true differences between studies using the I^2 statistic.**

Results: **Eighty-three studies, of which 80 were nonrandomized, met eligibility criteria. Compared with the prosthetic access, the autogenous access was associated with a significant reduction in the risk of death (RR, 0.76; 95% CI, 0.67-0.86; I^2 = 48%, 27 studies) and access infection (RR, 0.18; 95% CI, 0.11-0.31; I^2 = 93%, 43 studies), and a nonsignificant reduction in the risk of postoperative complications (hematoma, bleeding, pseudoaneurysm and steal syndrome, RR 0.73; 95% CI, 0.48-1.16; I^2 = 65%, 31 studies) and length of hospitalization (pooled weighted mean difference −3.8 days; 95% CI, −7.8 to 0.2; P = .06). The autogenous access also had better primary and secondary patency at 12 and 36 months.**

Conclusion: **Low-quality evidence from inconsistent studies with limited protection against bias shows that autogenous access for chronic hemodialysis is superior to prosthetic access. (J Vasc Surg 2008;48:34S-47S.)**

Several studies have demonstrated that autogenous arteriovenous access for chronic hemodialysis has longer patency compared with prosthetic access.[1,2] The National Kidney Foundation Dialysis Outcomes Quality Initiative (NKF KDOQI) advocates the use of autogenous access if possible in all clinical scenarios.[3]

Nevertheless, the prosthetic access is widely used in the United States, to the extent that in 2002, it represented 80% of accesses used in prevalent dialysis patients compared with 24% in Europe.[4] The increased use of prosthetic access may be attributed to putative benefits in some patients such as women and the elderly,[5-7] the availability of off-the-shelf conduit for placement, the higher reimbursement associated with prosthetic access placement, the ability to cannulate and use the prosthetic access without waiting for maturation, more amenability of the prosthetic access to thrombectomy, and the high nonmaturity rate of the autogenous access.[8-10] To our knowledge, no published systematic reviews have evaluated the two types of accesses in terms of patient-important outcomes other than patency, such as death and sepsis.

To aid physicians and patients in making informed choices about the placement and management of hemodialysis access, the Society for Vascular Surgery created a multispecialty committee to produce clinical practice guidelines based on the best available evidence. The aim of this review is to inform the development of these guidelines and compare the two types of accesses in terms of patient-important outcomes.

METHODS

The report of this protocol-driven systematic review was approved by the Society for Vascular Surgery and adheres to the standards for reporting Meta-analysis Of Observational Studies in Epidemiology (MOOSE).[11] Whenever possible, we used the nomenclatures and def-

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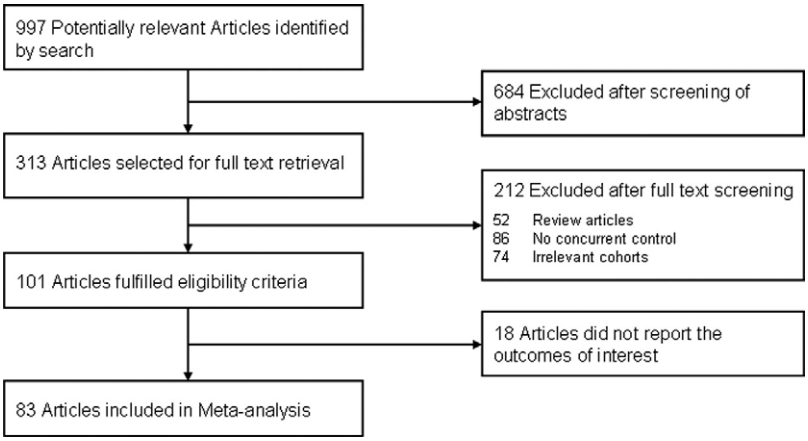

Fig 1. Flow chart shows study selection.

initions as published in the "Recommended Standards for Reports Dealing with Arteriovenous Hemodialysis Accesses" by the Society for Vascular Surgery.[12]

Eligibility criteria. We sought to include randomized controlled trials (RCTs) and cohort studies that compared a group of patients that have an autogenous access with a concurrent comparison group that had a prosthetic access. The outcomes of interest were death, access infection, postoperative complications, the duration of hospitalization due to access complications, and patency. We included studies regardless of their language, size, or duration of patient follow-up.

Study identification. An expert reference librarian designed and conducted the electronic search strategy with input from study investigators with expertise in conducting systematic reviews. To identify eligible studies, we searched electronic databases (MEDLINE, EMBASE, Cochrane CENTRAL, Web of Science and SCOPUS) through March 2007. The search strategy, which was tailored to each database, included controlled vocabulary and text words describing vascular access in hemodialysis (including terms for renal disease, methods of vascular access, and access type). We also sought references from experts, bibliographies of included studies, and the ISI Science Citation Index for publications that cited included studies (details are available from the authors upon request).

References were uploaded in a Web-based software package developed for systematic review data management (SRS, TrialStat Corporation, Ottawa, Ontario Canada). Paired reviewers working independently screened all abstracts and titles for eligibility. References that were deemed potentially relevant were retrieved in full text and uploaded for full text evaluation against eligibility criteria. Disagreements were resolved by consensus (the two reviewers discussed the study and reached a consensus) and by arbitration (a third reviewer adjudicated the study) when disagreement continued.

Data collection. Teams of reviewers working independently and in duplicates and using standardized forms extracted descriptive, methodologic, and outcome data from all eligible studies. Outcomes were extracted from text, tables, and graphs (survival curves). Study quality was assessed using the Newcastle-Ottawa Scale for assessing the quality of observational studies.[13] We sent e-mails to authors of all included studies to obtain missing data and to verify the presence of any collected but unreported data. When e-mail addresses were not published (particularly for older studies), we searched for authors' newer publications or attempted to contact their institutions to obtain current e-mail addresses.

Statistical analysis

Meta analyses. We pooled relative risks (RR) from each trial using the DerSimonian-Laird random effects model and estimated the 95% confidence intervals (CIs) for each outcome.[14] Patency rates were converted to dichotomous outcomes for specific time periods (12 and 36 months).[6] In all analyses in this review, a RR <1.0 indicates benefit from autogenous access vs prosthetic access. We assessed the heterogeneity among studies using the I^2 statistic, which represents the proportion of variability across studies that is not due to chance or random error but rather is due to real differences in study design, population, or interventions.[15] I^2 values of 25%, 50%, and 75% indicate low, moderate, and high heterogeneity, respectively. Statistical analysis was conducted by using Comprehensive Meta-Analysis 2 software (Biostat Inc, Englewood, NJ; 2005).

Subgroup analyses. A priori hypotheses to explain potential heterogeneity in the direction and magnitude of effect among included studies were patients' age (children vs adult, age $\geq$65 vs $<$65 years), gender, diabetes status, the presence of peripheral vascular disease, the location of the access (upper arm vs lower arm), and whether studies reported outcomes per patient or per access and whether patients were incidental or prevalent hemodialysis patients. Also, we conducted meta-regression to determine whether study quality or the length of study follow-up (predictor variables) affected patency outcomes (dependent variable).

Table I. Baseline characteristics for included studies

First author, year	*Patients, No.*	*Mean Age, y*	*Incidental/ prevalent*	*Autogenous*	
				Location	*Vessels*
Haimov,[17] 1980	126[a]	NR	Inc	Upper arm	Brachiocephalic
Mangiarotti,[18] 1983	205	NR	NR	Forearm, upper arm, thigh	36.96 brachial, 7.04 radial; 22.88 cephalic vein, 7.04 basilic, 14.08 other veins
ATordoir,[19] 1983	149	49	Inc	Forearm	Radiocephalic
Louridas,[20] 1984	152	43	NR	Forearm, upper arm	Radiocephalic, brachiocephalic
Winsett,[21] 1985	508	45	Prev	Forearm	Radiocephalic, brachiocephalic
Kherlakian,[22] 1986	200	52	Inc	Forearm	Radiocephalic
Zibari,[23] 1988	230	52	Mixed	Forearm, upper arm	Brachiocephalic, radiocephalic
Filiptsev,[24] 1989	84	NR	NR	Multiple (shoulder, upper arm, thigh)	NR
Nazzal,[25] 1990	125	37	Inc	Forearm, upper arm	Radiocephalic, brachiocephalic
Sands,[26] 1992	111	64	NR	NR	NR
Churchill,[27] 1992	347	≥18	Inc	NR	NR
Tang,[28] 1992	63	50	Prev	NR	NR
Sanabia,[29] 1993	74	9	Inc	Upper arm, forearm	Radiocephalic, ulnar basilic, antecubital
Taylor,[30] 1993	1897	NR	Inc	NR	NR
Al-Wakeel,[31] 1994	105	42	Inc	Forearm, upper arm	Radiocephalic, brachiocephalic
Bender,[32] 1994	68	62	Mixed	Elbow, wrist	Radiocephalic, brachiocephalic
Chalabi,[33] 1994	84	51	Inc	NR	Saphenous vein
Coburn,[34] 1994	81	65	Inc	Upper arm	Brachiobasilic
Riordan,[35] 1994	464	48	Inc	Forearm	Radiocephalic
Chazan,[36] 1995	117	57	Prev	NR	NR
Kim,[37] 1995	172	43	NR	NR	NR
Sands,[38] 1995	107	NR	Inc	NR	NR
Tedoriya,[39] 1995	113	47	Inc	Forearm, upper arm	Radiocephalic, ulnar basilic, snuffbox, brachiocephalic
Vaccaro,[40] 1995	276	56	Prev	Forearm	Radiocephalic
Enzler,[41] 1996	414	44	Mixed	Forearm, upper arm	NR
Herzig,[42] 1997	391	58	Inc	Multiple	NR
Hodges,[43] 1997	350	59	Inc	Forearm, upper arm	Radiocephalic, brachiocephalic
Miller,[44] 1997	76	64	Inc	Forearm, upper arm	Cephalic, brachial, radial, basilic
Sparks,[45] 1997	427	54	Inc	Forearm, upper arm	Radiocephalic, brachiocephalic, brachiocubital
Woods,[46] 1997	784	66	Mixed	NR	NR
Bay,[47] 1998	2792	60	Prev	Upper arm (6.4%), forearm (20.6%)	NR
Miranda,[48] 1998	1308[a]	NR	Prev	Forearm or upper arm	Cephalic or basilic veins
Berardinelli,[49] 1998	348	72	Inc	Forearm, upper arm	Radiocephalic, brachiocephalic
Bosman,[50] 1998	131	60	Inc	Forearm, upper arm, thigh	Denatured homologous vein graft, straight radiocephalic, loop radiocephalic, brachiocephalic, femoral.
Cante,[51] 1998	51	74	Inc	Forearm	NR
Jenkins,[52] 1980	56	NR	Inc	Forearm, upper arm, thigh	Radiocephalic, brachiocephalic, femoral
Matsuura,[53] 1998	98	61	Inc	Upper arm	Brachioaxillary, basilic vein transposition
Obialo,[54] 1998	36	42	NR	Forearm	Radio cephalic
Silva,[55] 1998	172	63	Inc	Forearm, upper arm	NR
Wang,[56] 1998	131	60	Prev	Multiple	NR
Agarwal,[57] 1999	32	56	Prev	NR	NR
Turnbull,[58] 1999	166	NR	Inc	Forearm, upper arm	Radiocephalic, brachiocephalic, brachiobasilic
Ascher,[59] 2000	247	69	Inc	Forearm, upper arm	Radiocephalic, brachiocephalic, brachiobasilic
Astor,[5] 2000	833	63	Prev	NR	NR
Rodriguez,[60] 2000	544	56	NR	Forearm, upper arm	Radiocephalic, brachiocephalic, humerobasilar
Staramos,[61] 2000	114	78	Inc	Forearm, upper arm	Radiocephalic, brachiocephalic, basilic transposition
Brunori,[62] 2000	203	68	Inc	Forearm, upper arm	Radiocephalic, brachiocephalic

Table I. Continued.

Prosthetic			
Location	*Vessels*	*F/U, d*	*Study design*
Forearm, upper arm, thigh	Radiocephalic, brachiocephalic, femoral	NR	Prosp
Forearm, upper arm, thigh	22 brachial, 1 arterial stump from prosthesis; 8 brachial, 8 basilic, 3 cephalic, 4 other veins	1740	Retro
Forearm, upper arm, thigh	Radiocephalic, brachiocephalic, saphenofemoral	1145	Prosp
Forearm, upper arm, thigh	Brachial to axillary, axillary to femoral, axillary to basilic, axillary to cephalic	NR	Retro
Forearm	Radiocephalic, brachiocephalic, brachiocubital	730	Retro
Upper arm, thigh	Brachiocephalic, brachiobasilic, femoral	1095	Retro
Forearm, upper arm, thigh	Radiocephalic, brachioaxillary, femoral, femoral-popliteal	NR	Retro
Multiple (shoulder, upper arm, thigh)	NR	NR	Prosp
Upper arm	Brachioaxillary	300	Prosp
NR	NR	180	Retro
NR	NR	NR	Prosp
NR	NR	300	Prosp
Forearm, upper arm, thigh, neck	Radiocephalic, brachiocephalic, brachiojugular, femoral	NR	Retro
NR	NR	NR	Retro
Forearm, upper arm	Radiocephalic, brachiocephalic	1825	Retro
Forearm, upper arm	NR	1095	Retro
Upper arm	Humeroaxillary, humerobasilic, humerocephalic	1825	Retro
Upper arm	Brachiobasilic, Brachioaxillary, Brachiocephalic	NR	Retro
Forearm, upper arm, thigh	Radiocephalic, brachiocephalic, femoral	NR	Retro
NR	NR	425	Prosp
NR	NR	510	Retro
NR	NR	772	Retro
NR	NR	6570	Retro
Upper arm	PTFE	730	Retro
Forearm, upper arm, thigh	NR	NR	Retro
Multiple	NR	NR	Retro
Forearm, upper arm, thigh	NR	NR	Retro
Upper arm	Brachiocephalic loop or straight graft	455	Retro
Upper arm	Loop brachial-cephalic/basilic or a bridge radial-cephalic/basilic construction.	1026	Retro
NR	NR	365	Retro
Forearm straight (14.7%), forearm loop (24.8%), upper arm straight (26.1%), upper arm loop (3.8%), femoral graft (2.3%)	NR	365	Prosp
Forearm, upper arm, thigh, chest	Cephalic, basilic, femoral, axillary	180	Retro
Forearm, upper arm	Radiocephalic, brachiocephalic	5475	Retro
Forearm, thigh	PTFE: loop radiocephalic, straight radiocephalic, femoral	326	RCT
Forearm	NR	730	Retro
Forearm, upper arm, thigh	Radiocephalic, brachiocephalic, femoral	NR	Prosp
Upper arm	Brachioaxillary	NR	Retro
Upper arm	Brachiocephalic	365	Prosp
Forearm, upper arm	Radiocephalic, brachioaxillary	401	Prosp
Multiple	NR	180	Prosp
NR	NR	252	Prosp
Forearm, upper arm	Radiocephalic, brachiocephalic, straight, loop	NR	Retro
NR	NR	270	Retro
NR	NR	395	Retro
Upper arm, thigh	Humerocephalic, humerobasilic, femoro-femoral	2532	Retro
Forearm, upper arm, thigh	Brachiocephalic, brachioaxillary, femoral	1095	Prosp
NR	NR	NR	Retro

Table I. Continued.

First author, year	*Patients, No.*	*Mean Age, y*	*Incidental/ prevalent*	*Autogenous*	
				Location	*Vessels*
Dhingra,[63] 2001	4469	59	Prev	NR	NR
Gibson,[64] 2001	152	56	Mixed	NR	NR
Gibson,[65] 2001	1583	66	Inc	NR	NR
Oliver,[66] 2001	195	57	Inc	Upper arm	Brachiocephalic, brachiobasilic transposition
Dixon,[67] 2002	204	56	Inc	Forearm, upper arm	Radiocephalic, brachiocephalic
Lawrence,[68] 2002	71	57	Prev	NR	NR
Pastan,[69] 2002	7403	58	Prev	NR	NR
Ridao-Cano,[70] 2002	872	56	Inc	Forearm, upper arm	Radiocephalic, basiocephalic
Saxena,[71] 2002	218	48	Prev	NR	NR
Sheth,[72] 2002	34	13	Inc	Forearm, upper arm, thigh	Radiocephalic, brachiocephalic, femoral
Valentine,[73] 2002	72	57	Inc	Upper arm	Brachial-based arteriovenous fistula
Johnson,[74] 2002	207	> 50	NR	Wrist, elbow	NR
Baaran,[75] 2003	2950	38	Inc	Forearm, upper arm	Radiocephalic, brachiocephalic
Cernadas,[76] 2003	60	61	Inc	Upper arm	Transposed brachiobasilic
Choi,[77] 2003	97	54	NR	Forearm, upper arm	Radiocephalic, brachiocephalic, brachiobasilic, transposed, non-transposed
Culp,[78] 1995	267	62	Inc	Forearm, upper arm	NR
Fisher,[79] 2003	197	61	Inc	Forearm, upper arm	Radiocephalic, brachiocephalic
Shenoy,[80] 2003	1110	59	Prev	NR	NR
Xue,[81] 2003	25226	>=67	Mixed	NR	NR
Yu,[82] 2003	82	61	Prev	NR	NR
Di Iorio,[83] 2004	2201	62	Prev	NR	NR
Hazinedaroglu,[84] 2004	30	59	Inc	Thigh	Femoral vein transposition
Kizilisik,[85] 2004	93	61	Inc	Forearm, upper arm	Radiocephalic, brachiocephalic, brachiobasilic
Perera,[86] 2004	209	57	Inc	Upper arm	Radiocephalic mainly, brachiocephalic. Basilic vein used in 4
Polkinghorne,[87] 2004	2632	>18	Inc	NR	NR
Akoh,[88] 2005	151	62	Inc	Forearm, upper arm	Brachiocephalic, radiocephalic
Astor,[89] 2005	206	59	Inc	NR	NR
Fitzgerald,[90] 2005	146	56	Inc	Upper arm	Brachiocephalic, brachiobasilic, brachiomedian
Kawecka,[91] 2005	722	44	Mixed	Upper and lower extremities	Radiocephalic, brachiocephalic and brachiobasilic
Manns,[92] 2005	239	63	NR	Forearm, upper arm	Radiocephalic, brachiocephalic
Ramage,[93] 2005	114	12	Inc	Upper arm	Radiocephalic, brachiocephalic
Rooijens,[94] 2005	383	60	Inc	Forearm	Radiocephalic
Ates,[95] 2006	920	42	Inc	Forearm, upper arm	Radiocephalic, brachiocephalic
Roca-tey,[96] 2006	89	63	Prev	Upper arm	Radiocephalic, brachiocephalic
Woo,[97] 2007	329	65	Prev	Upper arm	NR
Keuter,[98] 2008	105	63	Prev	Upper arm	Brachial-basilic

F/U, Follow-up, *Inc,* incidental dialysis patients; *NR,* not reported; *Prev,* prevalent dialysis patients; *Pros,* prospective; *PTFE,* polytetrafluoroethylene; *Retro,* retrospective; *RCT,* randomized controlled trial.

[a]This is the number of accesses; number of patients is not reported.

[b]Communication with author indicates that patients and care givers were not blinded, data collectors were blinded, and allocation was concealed.

Sensitivity analyses. We conducted sensitivity analyses to test the effect of including studies in which investigators determined study outcomes clinically or from administrative databases (eg, billing codes). Using billing/administrative data to determine outcomes reduces the bias caused by outcome assessors not being blinded but introduces misclassification bias (intentional or unintentional erroneous coding). We conducted sensitivity analysis with and without the assumption that denatured homologous vein grafts and saphenous vein grafts are considered autogenous accesses. We also explored the robustness of our results by analyzing the data with accounting for censoring in time-to-event outcomes according to the method of Pramar et al.[16]

RESULTS

Study identification. Our search and selection procedures yielded 995 potentially eligible references, of which 99 proved eligible and 83 provided data for meta-analyses (Fig 1). Study characteristics are summarized in Table I.[5,17-98] The chance adjusted inter-reviewer agree-

Table I. Continued.

Prosthetic			
Location	*Vessels*	*F/U, d*	*Study design*
NR	NR	730	Prosp
NR	NR	511	Retro
NR	NR	340	Retro
Upper arm	Brachioaxillary	600	Retro
Forearm	Forearm loop radiocephalic	1825	Prosp
NR	NR	NR	Retro
NR	NR	260	Retro
Forearm, upper arm	Radiocephalic, brachiocephalic, straight, loop grafts	1825	Retro
NR	NR	1460	Prosp
Forearm, upper arm, thigh	Radiocephalic, brachiocephalic, femoral	3650	Retro
Upper arm, forearm	Radiocephalic, brachiocephalic, straight or loop	180	Prosp
NR	NR	360	Prosp
Upper arm	NR	1160	Retro
Upper arm	PTFE brachioaxillary bridge fistula	730	Retro
Forearm, upper arm	Brachioaxillary, mediocubital, cephalic or basilic vein	545	Retro
Forearm, upper arm	NR	365	Prosp
Forearm, upper arm, thigh	Forearm loop, upper arm loop, thigh loop	780	Retro
NR	NR	730	Retro
NR	NR	365	Retro
NR	NR	365	Prosp
NR	NR	730	Retro
Thigh	Superficial femoral artery to saphenous or common femoral vein	237	Prosp
Forearm, upper arm	Straight, loop	600	Retro
Upper arm	Brachial mainly, radial. Outflow brachial/axillary, basilic vein	1095	Retro
NR	NR	1095	Retro
Forearm, upper arm, chest, thigh	Forearm straight, forearm loop, brachioaxillary, femoral, axillary	567	Retro
NR	NR	810	Retro
Forearm	Brachiobasilic, brachiocephalic, brachiomedian	430	Retro
Upper and lower arm	NR	570	Retro
Upper arm	Brachiocephalic	NR	Retro
Forearm, upper arm, thigh	Radiocephalic, brachiocephalic, femoral	7300	Retro
Forearm	Brachiocephalic	365	RCT
Upper arm	Brachioaxillary, brachiocephalic	1825	Retro
Upper arm, thigh	Brachiocephalic, femoral	354	Prosp
Upper arm	NR	860	Retro
Forearm	Brachial antecubital forearm loop	365	RCT[b]

ment (κ statistic) for study eligibility averaged 0.78 (range, 0.61-1.00). These studies enrolled 69,816 participants (mean size, 850 patients; mean age, 55 years; mean follow-up, 2.8 years). Authors from 26 of the 83 included studies (31%) responded to our e-mail queries and provided missing data. Seven studies were translated to English.[1,24,99,40,100-102]

Methodologic quality. Three studies were open randomized trials,[50,94,98] and 80 were observational studies, of which 56 had a retrospective cohort design and 24 had a prospective cohort design. Allocation was concealed and data collectors were blinded in one of the randomized trials.[98] The distribution of the Newcastle-Ottawa quality scale components that describe the quality of observational studies are summarized in Table II. Only 46% of the studies controlled for at least one possible confounder in cohort selection or analysis. The proportion lost to follow-up was <10% in only 19% of the studies. Only 20% of the studies reported a funding source. Inter-reviewer agreement (κ statistic) of the different components of quality averaged 0.70 (range, 0.53-1.00).

Meta-analyses. The autogenous access was associated with a significant reduction in the risk of death (RR, 0.76; 95% CI, 0.67-0.86; I^2 = 48%; 27 studies; Fig 2) and access infection (RR, 0.18; 95% CI, 0.11-0.31; I^2 = 93%; 43 studies; Fig 3). The autogenous access was also associated with a nonsignificant reduction in the risk of postoperative complications of access placement other than infection, including hematoma, bleeding, pseudoaneurysm, and steal syndrome (RR, 0.73; 95% CI, 0.48-1.12; I^2 = 65%, 31

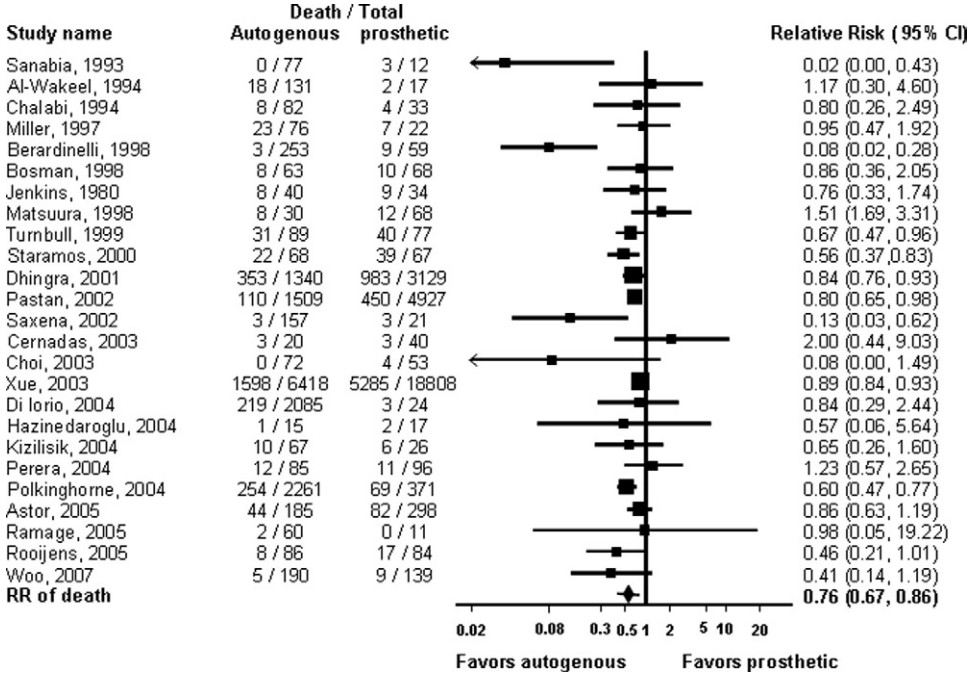

Fig 2. Meta-analysis of the effect of access type on the risk of death. The *vertical line* indicates no treatment effect; the *squares* and *horizontal lines*, point estimates and associated 95% confidence intervals *(CIs)* for each study; *diamonds,* random-effects pooled relative risk *(RR)* of death.

Table II. Distribution of components of the Newcastle-Ottawa quality scale of cohort studies

Component	*Studies, No. (%)*
Cohort selection	
Study cohorts are representative of the typical patients encountered in practice	
Yes	77 (96)
No or not reported	3 (4)
Exposure ascertainment (type of access)	
Adequate (clinical exam or chart review)	63 (79)
Inadequate (self-report or not reported)	17 (21)
Studies confirmed that the access was functional at the outset	
Yes	20 (25)
No or not reported	60 (75)
Cohort comparability	
Studies controlled for possible confounders in cohort selection or analysis	
Controlled for 2 or more confounders	30 (37)
Controlled for one confounder	7 (9)
Did not control for confounders	43 (54)
Outcome	
Outcome assessment	
Adequate (physical exam, chart review, record linkage)	56 (70)
Inadequate (self-report, not reported)	24 (30)
The length of follow-up adequate to assess outcomes	
equal or >12 months	47 (59)
<12 months	33 (41)
Proportion lost to follow-up	
≤10%	15 (19)
>10%	65 (81)

studies; Fig 4). The length of hospitalization related to access complications was lower in patients who had autogenous accesses (pooled weighted mean difference –3.8 days; 95% CI –7.8 to 0.2; $P = .06$; 3 studies).

Primary and secondary patency rates at 12 and 36 months were significantly higher in the autogenous than in the prosthetic access. RRs for access failure without interventions to maintain or re-establish patency were 0.72 (95% CI, 0.65-0.80) at 12 months and 0.67 (95% CI, 0.58-0.78 at 36 months. RRs for access failure including interventions to maintain or re-establish patency were 0.83 (95% CI, 0.70-0.99) at 12 months and 0.67 (95% CI, 0.61-0.74) at 36 months.

Subgroup analyses. One of the a priori established analyses to explain heterogeneity of results is autogenous access location (upper arm vs lower arm, both compared with prosthetic access at any location). We found a significant access location–access complications interaction ($P = .02$) demonstrating that the magnitude of benefit from autogenous access vs prosthetic access is significantly more when autogenous access was placed in the lower arm. There were no significant death–access location, access infection–access location or patency–access location interactions ($P = .60$, $P = .18$, and $P = .33$, respectively).

Only two studies compared the autogenous upper arm access with a prosthetic lower arm access (prosthetic looped forearm access).[90,98] Pooling the outcomes of the two studies (a total of 249 patients) demonstrates that the placement of autogenous access in the upper arm is associ-

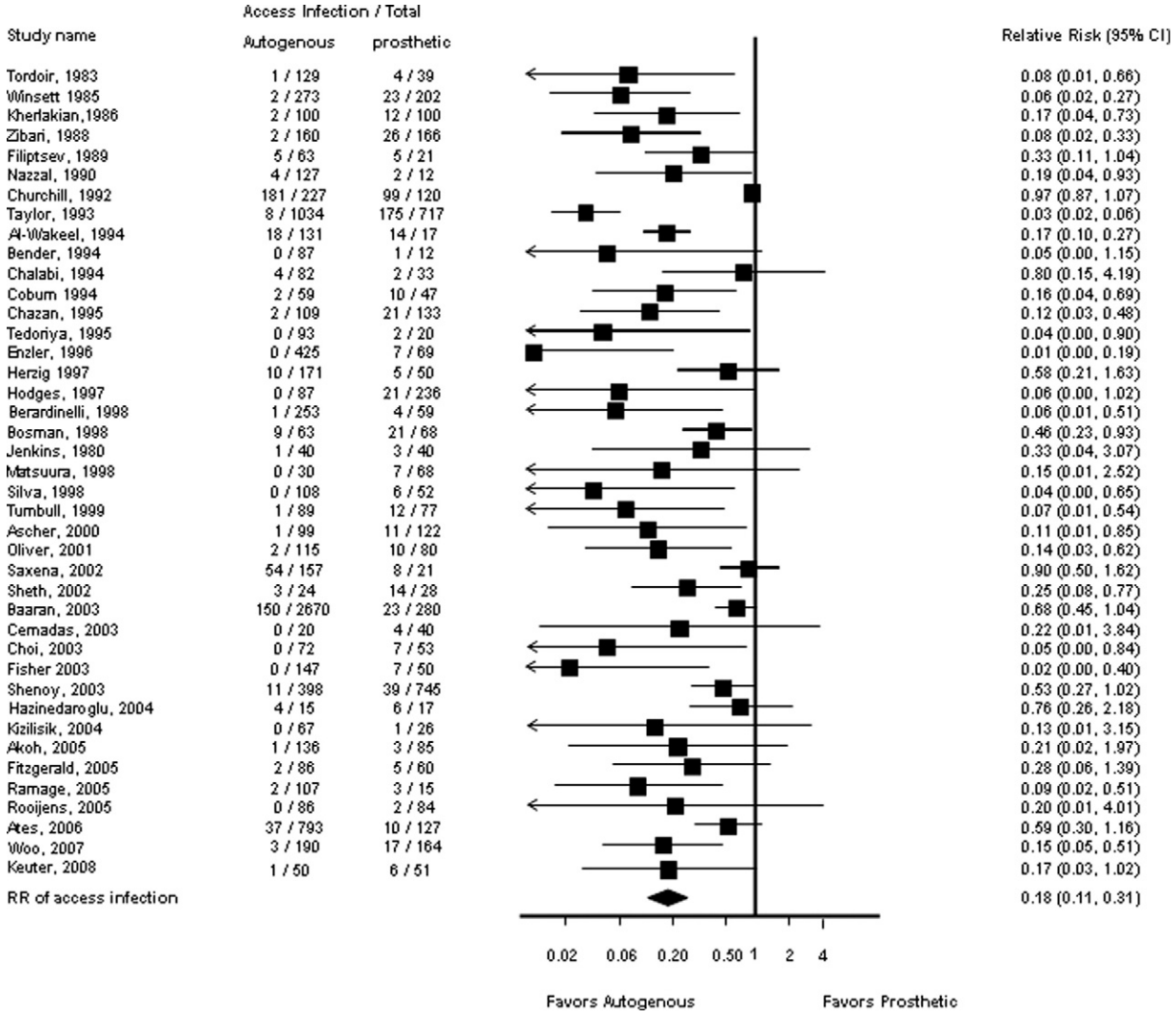

Fig 3. Meta-analysis of the effect of access type on the risk of access infection. The *vertical line* indicates no treatment effect; *squares* and *horizontal lines*, point estimates and associated 95% confidence intervals (*CIs*) for each study; *diamonds*, random-effects pooled relative risk *(RR)* of access infection.

ated with a significantly lower rate of infections (RR, 0.23; 95% CI, 0.07-0.83) and nonsignificant trends for better 12-month primary (RR, 0.88; 95% CI, 0.72-1.07) and secondary (RR, 0.81; 95% CI, 0.54-1.20) patency. Patency at 24 months was only reported by Fitzgerald et al[90] and was similar between the two accesses. Both studies reported the upper arm placement of autogenous access to be associated with fewer complications and to require fewer interventions to maintain patency.

Interactions based on patient type (incidental vs prevalent hemodialysis) for outcomes of death, access infections, access complications, and patency were all nonsignificant ($P = .4$, $P = .77$, $P = .43$, and $P = .33$, respectively).

Several studies reported outcomes by access rather than by patient, a unit-of-analysis challenge given the likely correlation of outcomes for accesses in the same patient. However, the results in studies reporting patency, access complications, and access infection, per patient vs per access, were not different ($P = .80$, $P = .43$ and $P = .33$, respectively).

There were no significant patency-gender or patency-age (>65 or <65 years) interactions. A significant patency-age interaction (pediatric vs adults) was found in a single, small pediatric study that showed the autogenous access patency in children was inferior to that of the prosthetic access at 12 and 36 months ($P = .02$ and $P = .07$, respectively); however, autogenous patency regained superiority at 60 months of follow-up.[72] Subgroup analyses are summarized in Table III.

Meta-regression revealed that neither study quality nor the length of study follow-up explained the between-study variability in patency reported across studies. In terms of

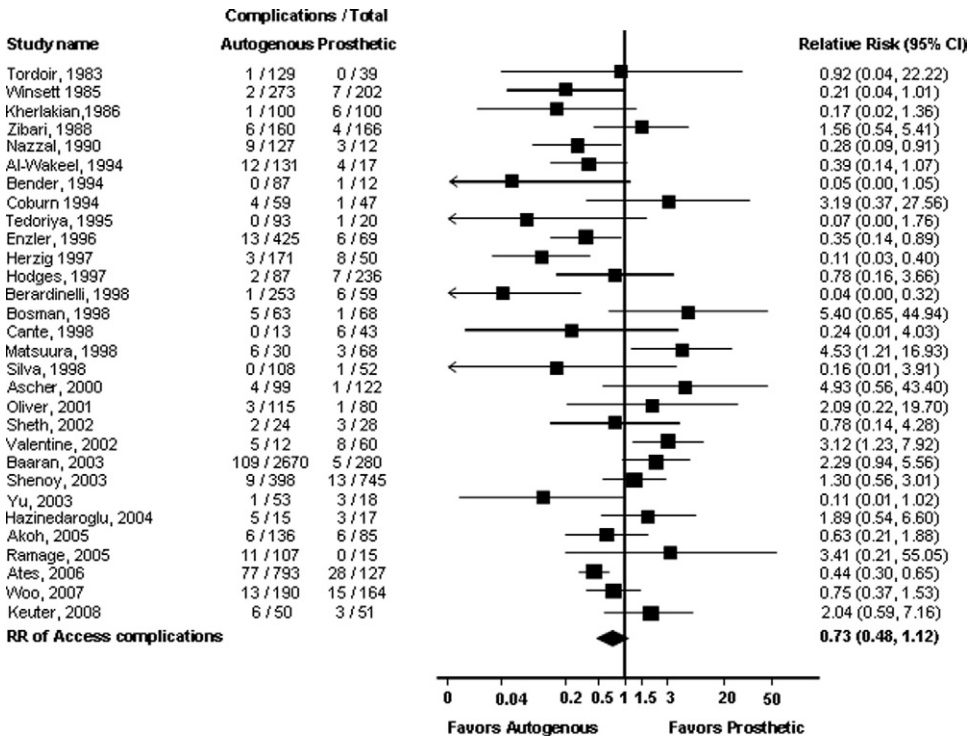

Fig 4. Meta-analysis of the effect of access type on the risk of access complications other than infection. The *vertical line* indicates no treatment effect; *squares* and *horizontal lines*, point estimates and associated 95% confidence intervals *(CIs)* for each study; *diamonds*, random-effects pooled relative risk *(RR)* of access complications.

diabetes status, the autogenous access was associated with longer patency[36] and lower mortality[63] than the prosthetic access in patients with and without diabetes. Hence, it appears that the presence of diabetes should not affect the choice of access.

Sensitivity analyses. Sensitivity analyses are summarized in Table IV. The exclusion of studies in which the autogenous access was denatured homologous vein graft or saphenous vein grafts and the exclusion of studies that used administrative and billing databases to determine outcomes caused no significant change in any of the results.

Because the shortest and longest follow-up times for study participants, which are the key variables in the adjustment for censoring of time-to-event data reported in graphic form, were either not reported or were similar in both study arms, adjustments for censoring were either not feasible or led to proportionate decrements of the sizes of both study arms, slightly widening the CIs without affecting the estimates of RR for any of the outcomes examined or their statistical significance (data not shown).

DISCUSSION

We conducted a systematic review and meta-analyses to compare the autogenous and prosthetic accesses for chronic hemodialysis in terms of patient-important outcomes. We found that very low-quality evidence[103] with significant heterogeneity suggests that the autogenous access of hemodialysis is superior to the prosthetic access in terms of the risks of death, access infection, and primary and secondary patency. Overall, there were insufficient data to identify a subgroup to which the overall conclusions do not apply, although subgroup analyses were underpowered.

Limitations and strengths. Although systematic reviews and meta-analyses comparing autogenous vs prosthetics accesses exist, [6,10] to our knowledge this is the first comprehensive review to assess patient-important outcomes other than patency. Efforts to reduce bias such as author contact, a review of the literature by two independent reviewers, and explicit quality assessment strengthen inferences from this review.

The main limitation of this review is the nonrandomized design of most of the included studies, which meant that the choice of access type was based on surgeons' preference, patients' comorbidities, and other unmeasured yet potentially important confounders. Although this inherent bias in observational studies can be remedied to some extent by controlling for factors that can affect study outcomes in either selecting cohorts or in analysis, we found that many studies did not control for these factors, rendering the cohort that received prosthetic access to include more patients with diabetes, patients with peripheral vascular disease, and older patients. This

Table III. Subgroup analyses

Variable	*Studies, No.*	*RR (95% CI)*	P *(interaction test)*
Death			
Upper arm autogenous vs prosthetic	6	0.68 (0.25-1.83)	0.55
Lower arm autogenous vs prosthetic	3	0.46 (0.21-1.01)	
Incidental HD patients	19	0.72 (0.58-0.89)	0.74
Prevalent HD patients	5	0.76 (0.60-0.97)	
Access infection			
Upper arm autogenous vs prosthetic	11	0.21 (0.12-0.36)	0.17
Lower arm autogenous vs prosthetic	5	0.10 (0.04-0.24)	
Studies that used access data	29	0.21 (0.12-0.35)	0.33
Studies that used patient data	13	0.34 (0.15-0.74)	
Incidental HD patients	30	0.22 (0.11-0.47)	0.77
Prevalent HD patients	5	0.26 (0.09-0.70)	
Access complications			
Upper arm autogenous vs prosthetic	9	1.22 (0.48-3.10)	0.02
Lower arm autogenous vs prosthetic	5	0.20 (0.06-0.68)	
Studies that used access data	21	0.69 (0.42-1.11)	0.43
Studies that used patient data	10	1.06 (0.41-2.71)	
Incidental HD patients	22	0.86 (0.48-1.53)	0.43
Prevalent HD patients	4	0.56 (0.23-1.35)	
Primary patency at 12 months			
Upper arm autogenous vs prosthetic	14	0.70 (0.56-0.88)	0.09
Lower arm autogenous vs prosthetic	11	0.94 (0.73-1.20)	
Males	2	0.50 (0.39-0.65)	0.64
Females	2	0.65 (0.22-1.88)	
Old (>65)	2	0.57 (0.25-1.32)	0.56
Young (≤65)	2	0.89 (0.25-3.15)	
Studies that used access data	28	0.68 (0.60-0.77)	0.51
Studies that used patient data	12	0.78 (0.60-1.03)	
Incidental HD patients	28	0.75 (0.65-0.87)	0.16
Prevalent HD patients	6	0.63 (0.52-0.77)	
Primary patency at 36 months			
Upper arm autogenous vs prosthetic	8	0.87 (0.66-1.14)	0.78
Lower arm autogenous vs prosthetic	4	0.80 (0.48-1.34)	
Studies that used access data	13	0.65 (0.54-0.78)	0.08
Studies that used patient data	5	0.83 (0.67-1.01)	
Incidental HD patients	15	0.75 (0.59-0.94)	0.16
Prevalent HD patients	6	0.59 (0.48-0.73)	
Secondary patency at 12 months			
Upper arm autogenous vs prosthetic	9	0.70 (0.51-0.96)	0.07
Lower arm autogenous vs prosthetic	7	0.99 (0.82-1.20)	
Pediatric studies	1	6.67 (1.13-41.46)	0.02
Adult studies	22	0.82 (0.62-0.99)	
Studies that used access data	18	0.82 (0.66-0.97)	0.45
Studies that used patient data	5	0.95 (0.68-1.32)	
Incidental HD patients	15	0.88 (0.69-1.13)	0.70
Prevalent HD patients	4	0.97 (0.63-1.50)	
Secondary patency at 36 months			
Upper arm autogenous vs prosthetic	8	0.73 (0.60-0.90)	0.33
Lower arm autogenous vs prosthetic	6	0.65 (0.58-0.73)	
Pediatric studies	1	1.69 (0.63-4.53)	0.07
Adult studies	18	0.67 (0.60-0.76)	
Studies that used access data	16	0.67 (0.59-0.75)	0.80
Studies that used patient data	3	0.71 (0.46-1.09)	
Incidental HD patients	12	0.72 (0.60-0.85)	0.33
Prevalent HD patients	4	0.61 (0.46-0.81)	

CI, Confidence interval; *HD,* hemodialysis; *RR,* relative risk.

bias in selection has likely overestimated the benefit noted in patients who received the autogenous access. Moreover, the proportion of studies that contributed to each of the outcomes in this review was low; thus, reporting bias has likely affected the benefits noted with autogenous access placaement.[104]

Other limitations relate to extracting survival data from graphs and to the inconsistency of the taxonomy in the included studies, which underscores the need for standardized nomenclature.[12] In addition, one study[33] could not be retrieved and was extracted directly from a previously published systematic review.[6]

Table IV. Sensitivity analysis

Variable	*Studies, No.*	*RR (95% CI)*
Death		
Pooled estimate from all included studies	27	0.76 (0.67-0.86)
Excluding studies that used administrative data to assess outcomes	25	0.71 (0.60-0.84)
Excluding DHV and saphenous vein grafts from autogenous group	25	0.75 (0.65-0.86)
Primary patency at 12 months		
Pooled estimate from all included studies	41	0.71 (0.64-0.80)
Excluding DHV and saphenous vein grafts from autogenous group	39	0.70 (0.62-0.78)
Excluding studies that used administrative data to assess outcomes	38	0.70 (0.62-0.80)
Adjustment for censoring applied	30	0.72 (0.62-0.84)
Adjustment for censoring not applied	30	0.72 (0.62-0.83)
Primary patency at 36 months		
Pooled estimate from all included studies	24	0.67(0.58-0.78)
Excluding studies that used administrative data to assess outcomes group	22	0.68 (0.58-0.81)
Adjustment for censoring applied	20	0.73 (0.59-0.90)
Adjustment for censoring not applied	20	0.72 (0.58-0.90)
Secondary patency at 12 months		
Pooled estimate from all included studies	24	0.84 (0.71-1.00)
Excluding DHV and saphenous vein grafts from autogenous group	22	0.84 (0.69-1.02)
Excluding studies that used administrative data to assess outcomes	22	0.83 (0.67-1.03)
Adjustment for censoring applied	21	0.84 (0.70-1.00)
Adjustment for censoring not applied	21	0.83 (0.70-0.99)
Secondary patency at 36 months		
Pooled estimate from all included studies	20	0.67 (0.61-0.74)
Adjustment for censoring applied	19	0.64 (0.54-0.74)
Adjustment for censoring not applied	19	0.63 (0.55-0.73)

CI, Confidence interval; *DHV,* denatured homologous vein grafts; *RR,* relative risk.

CONCLUSIONS

Although the available evidence is consistent with previous recommendations for using autogenous accesses for hemodialysis, the current review highlights that this inference is derived from very low-quality evidence. That is, large studies with better protection against bias—preferably randomized trials measuring patient important outcomes—are necessary to make recommendations with confidence because these may substantially change the estimates reported here. Patient and surgeon preferences, cost considerations, and clinical circumstances should inform the choice of access for specific patients. The accompanying practice guideline document includes the practical implication of this evidence from the standpoint of the expert members of the committee of the Society for Vascular Surgery.

AUTHOR CONTRIBUTIONS

Conception and design: MHM, AS, AD, PE, VM
Analysis and interpretation: MHM, VM
Data collection: MHM, ME, AS, GM, AR, DF, EC, FM, MM, DV, ZE, MT, PE
Writing the article: MHM, ME, AS, GM, AR, DF, EC, FM, MM, DV, ZE, AD, PE, VM
Critical revision of the article: MHM, ME, AS, GM, AR, DF, EC, FM, MM, DV, ZE, AD, PE, VM, MT
Final approval of the article: MHM, ME, AS, GM, AR, DF, EC, FM, MM, DV, ZE, AD, PE, VM, MT
Statistical analysis: MHM
Obtained funding: VM
Overall responsibility: MHM

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